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(54) **A method for preparing low free formaldehyde methylol-hydantoins and compositions thereof**

Methode um Methylol-Hydantoine mit niedriger Konzentration an freiem Formaldehyd, Herstellung und deren Zusammensetzungen

Méthode de préparation de méthylol-hydantoines à faible teneur en formaldéhyde libre, ainsi que leurs compositions

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- **PATENT ABSTRACTS OF JAPAN vol. 017, no. 225 (C-1055)10 May 1993 & JP-A-43 60 873**

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Description

This invention relates to the preparation of compositions comprising dimethyloldimethylhydantoin (DMDMH), monomethyloldimethylhydantoin (MDMH), and dimethylhydantoin (DMH) having less than 0.1% by weight of free formaldehyde based upon 100% by weight of total solution; wherein the weight ratio of DMDMH:MDMH ranges from about 1:1.25 to about 3.5:1. The compositions prepared according to the present invention are expected to meet and to surpass anticipated government formaldehyde content guidelines and to avoid other disadvantages of relatively high free formaldehyde content methylolhydantoin solutions, including unpleasant odor, skin irritation, loss of the volatiles of formaldehyde, and health hazards to production workers.

Formaldehyde is a well-known antimicrobial agent that has been used widely to extend the shelf life of certain preparations that are susceptible to microbial growth. These preparations may include industrial products such as liquid detergents, water-based surfactants, soft soaps, water-based paints, fabric softeners, room deodorizers/air fresheners, polymer emulsions, protective coatings for textiles, architectural coatings, water-based gels, sealants and caulks, latexes for paper coatings, water-based inks, wood preservatives, etc. They may also include personal care products such as cosmetics, shampoos, creams, lotions, powder products, etc.

However, formaldehyde, particularly in high concentrations, has many disadvantages, such as an unpleasant odor, a propensity to irritate skin, and a short shelf life due to its high volatility. More importantly, formaldehyde has come under increasingly greater scrutiny by the medical community and by regulatory agencies due to its potential as a health risk.

DMDMH is a formaldehyde donor which releases formaldehyde slowly over a relatively long period of time and is typically produced by methylolating one mole of DMH with two moles of formaldehyde. MDMH, another formaldehyde donor, is prepared also by the methylolation using one mole of formaldehyde.

The US-A-3,987,184, discloses a method for the production of DMDMH which involves reacting 1.85 to 2.4 moles of formaldehyde per mole of 5,5-DMH in water, at a pH of from about 7 to about 9, for a period of about 20 minutes, at a temperature of about 22° to 65°C. Foelsch hypothesized that DMDMH solutions prepared in this manner would have under 1% by weight of free formaldehyde, but he exemplified only solutions having 1.2% by weight of free formaldehyde.

Alternative methods for achieving low free formaldehyde in DMDMH solutions have included the addition of ammonium carbonate to DMDMH solutions or the vacuum stripping of residual free formaldehyde from DMDMH solutions. These attempts have been unsuccessful in lowering free formaldehyde content below 0.1% by weight, however.

The EP-A-0 391 645 describes a process for making essentially anhydrous methylolated hydantoins. The dry methylolated hydantoins are prepared by reacting a hydantoin, a formaldehyde and an alkaline catalyst at conditions of temperature and pressure sufficient to induce reaction to obtain products in essentially 100% active form. Aqueous solutions derived from the anhydrous products obtained by this process, however, still have a considerable content in free formaldehyde.

A direct reaction method and a post addition method have now been discovered which result in compositions of dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin having less than 0.1% by weight of free formaldehyde based upon 100% by weight of total composition, wherein the weight ratio DMDMH to MDMH ranges from about 1:1.25 to about 3.5:1. Compositions described above are produced which overcome many of the disadvantages of the prior art and which comply with anticipated stringent regulatory agency requirements.

According to the present invention, there is provided a method (the direct reaction method) for producing these compositions comprising reacting dimethylhydantoin and a formaldehyde-containing source wherein the molar ratio of formaldehyde to dimethylhydantoin ranges from about 1.2:1, and preferably 1.3:1, to about 1.55:1. A most preferred ratio is about 1.35:1.

In a further embodiment (the post addition method), an aqueous solution of dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin is produced by admixing (a) from about 80 to about 90% by weight of an aqueous solution of methylolated dimethylhydantoins having greater than 0.1% by weight of free formaldehyde with (b) about 20 to about 10% by weight of dimethylhydantoin based upon 100% by weight of aqueous solution of methylolated dimethylhydantoins and dimethylhydantoin combined.

Also contemplated by the invention are compositions comprising dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin having less than 0.1% by weight of free formaldehyde based upon 100% by weight of the composition, wherein the weight ratio of DMDMH to MDMH ranges from about 1:1.25 to about 3.5:1. Preferred compositions have from about 10 to about 25% by weight of total formaldehyde and from about 2 to about 6% by weight of dimethylhydantoin based upon 100% by weight of the composition. Preferred compositions are aqueous solutions and most preferably are stable as explained below.

These compositions are used in biocidal effective amounts in any medium in which microbial growth is to be retarded, and particularly in industrial or personal care products.

DMDMH is a formaldehyde donor which is the diformylated product of DMH and formaldehyde. MDMH is first formed as an intermediate, which itself is a formaldehyde scavenger containing about 19% by weight of bound, but

available, formaldehyde. Subsequent reaction of MDMH with formaldehyde yields DMDMH which theoretically contains 31.9% of bound, but available, formaldehyde. DMDMH is typically found commercially in aqueous solutions containing at least 1% by weight of free formaldehyde based upon 100% by weight of total DMDMH solution.

The Direct Reaction Method

The direct reaction method of the present invention involves reacting dimethylhydantoin and a formaldehyde containing source wherein the molar ratio of formaldehyde to dimethylhydantoin ranges from about 1.2:1 to about 1.55:1 and preferably from about 1.3:1 to about 1.55:1. Most preferably, the molar ratio is about 1.35:1.

The formaldehyde containing source suitable for use herein may be any known to one of ordinary skill in the art including, but not limited to, aqueous solutions of formaldehyde such as formalin or substantially anhydrous formaldehyde such as paraformaldehyde. Preferably, the formaldehyde containing source comprises from about 36 to about 38% by weight of formaldehyde based upon 100% by weight of aqueous formaldehyde solution or about 95% by weight of formaldehyde based upon 100% by weight of paraformaldehyde. Preferably, the pH of the aqueous formaldehyde solution ranges from 8.1 to 8.3 at the beginning of the reaction.

The compositions prepared by the direct reaction method can be prepared either as aqueous solutions or as substantially anhydrous compositions, i.e., less than 1% by weight of water. Additionally, these substantially anhydrous forms can be diluted to yield aqueous solutions.

In a preferred embodiment, the direct reaction method includes the use of an aqueous solution of formaldehyde having a pH of from 8.0 to 9.0, for example of from 8.2 to about 8.3, adjusting the pH of the initial dimethylhydantoin/aqueous formaldehyde solution reaction product to about 7, heating the pH adjusted product to a temperature ranging from about 45°C to about 55°C for a period of about 2 1/2 to 3 1/2 hours, cooling the heated product to about room temperature, and finally adjusting the pH to range of from about 6.2 to about 7.2, for example 6.8 to 7.2.

The Post Addition Method

The post addition method involves the admixing of from about 80 to about 90% by weight, preferably from about 83 to about 90% by weight, and most preferably about 85% by weight of an aqueous solution of methyloldimethylhydantoins having greater than 0.1% by weight of free formaldehyde with correspondingly from about 20 to about 10% by weight, preferably about 17 to about 10% by weight, and most preferably about 15% by weight of dimethylhydantoin. Preferably, the aqueous solution of dimethyloldimethylhydantoin has from about 10 to about 18% by weight of total formaldehyde and/or from about 25% to about 60% by weight of dimethyloldimethylhydantoin.

The post addition method of the present invention reduces the amount of free formaldehyde in DMDMH solutions prepared by any method. However, this method is not as well suited for commercial use as is the direct reaction method because the post addition method requires greater quantities of DMH than the direct reaction method. Additionally, post addition increases the solids content of the resultant stable, low free formaldehyde composition, and increased solids content can lead to undesirable crystallization of the product.

The compositions prepared by direct reaction or by post addition preferably have from about 10% to 25% by weight of total formaldehyde based upon 100% by weight of the total composition. Most preferably, total formaldehyde ranges from about 12 to about 17% by weight. In particular preferred embodiments, the total formaldehyde content is either 12% or 17% by weight. Preferably, the compositions of the present invention will have a pH ranging from about 6.5 to 7.5, but the pH can be adjusted according to need with aqueous sodium hydroxide or the like.

Preferred DMDMH/MDMH/DMH compositions of the present invention comprise from about 20 to about 40% by weight of dimethyloldimethylhydantoin based upon 100% by weight of composition. Most preferably, they comprise from about 25 to about 35% by weight of dimethyloldimethylhydantoin. Furthermore, preferred low free formaldehyde DMDMH/MDMH/DMH compositions comprise from about 2 to about 6% by weight of dimethylhydantoin based upon 100% by weight of composition.

Stability is defined as maintenance of less than 0.1% by weight of free formaldehyde for at least 30 days and preferably for at least six months.

Mixing of components and addition of components in the methods of the present invention can be accomplished by conventional means known to those of ordinary skill in the art.

A second post addition can be used as an adjunct to the direct reaction method as described herein, and in fact for any out-of-spec batches prepared by the present methods or other methods. Preferably in this type of post addition, DMH will be added to aqueous DMDMH/MDMH/DMH solutions at an amount of from about 1 to 10% by weight and preferably from about 1 to about 3% by weight based upon 100% by weight of total DMDMH/MDMH/DMH solution.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples illustrate the invention without limitation. All parts and percentages are given by weight unless otherwise indicated.

The following analytical methods were used. Free formaldehyde was determined by reaction with hydroxylamine hydrochloride. Each mole of formaldehyde liberates one mole of hydrogen chloride. The latter is determined potentiometrically by titration with alkali.

Carbon-13 NMR was used to determine composition (percentage of DMH, MDMH, and DMDMH) in the solutions.

Total formaldehyde was measured by one of two techniques. The first is the Hantzsch method where combined formaldehyde is liberated from the dimethylhydantoin ring by reaction with ammonium acetate and acetylacetone. Combined and free formaldehyde react with the latter two reagents to form 3,5-diacetyl-1,4-dihydrolutidine. The absorbance of the lutidine derivative is measured at 413 nanometers, and the formaldehyde is quantified by comparing to a calibration curve. The second means for measuring total formaldehyde is by alkaline oxidation. Formaldehyde is oxidized with hydrogen peroxide in a solution containing excess potassium hydroxide to form potassium formate. Excess potassium hydroxide is titrated potentiometrically with mineral acid.

Water was measured by the Karl Fischer technique.

The Direct Reaction Method

EXAMPLE 1

A 12 liter 3-necked round bottom flask equipped with a stirrer, a temperature regulator (Thermowatch™ and heating mantle), and a condenser was charged with 3133 grams of formalin (37% aqueous formaldehyde, 1.2% methanol) (39 moles formaldehyde) and 2163 grams of water. The pH was adjusted to 8.3 using aqueous sodium hydroxide. 3704 grams (29 moles) of DMH were added at room temperature in a molar ratio of formaldehyde to DMH of 1.35:1. An exotherm was observed, and the temperature increased to 31°C. After most of the DMH dissolved, the maximum temperature was reached, and the exotherm stopped. The pH was adjusted with aqueous sodium hydroxide to 7. The reaction was heated at 55°C for three hours and was then cooled to room temperature. The pH was then adjusted to a range of from 6.8 to 7.5. 5 grams of filter aid (diatomaceous earth) were added, and the product was filtered. The product was then analyzed again.

The product was then stored for six months at 25°C and subsequently analyzed again.

These procedures were repeated four additional times with similar results.

Representative properties are summarized in Table 1.

COMPARATIVE EXAMPLE 1A

An aqueous DMDMH/MDMH/DMH solution was prepared according to the procedure of Example 1. However, the amount of DMH added was adjusted so that the molar ratio of formaldehyde to DMH was 2:1.

Properties are summarized in Table 1.

Example 1, when compared with Comparative Example 1A, demonstrates that free formaldehyde content is kept below 0.1% by weight in aqueous DMDMH/MDMH/DMH solutions when the molar ratio of formaldehyde to DMH in the reaction is below 2:1 and particularly is 1.35:1.

Example 1 further demonstrates the effectiveness of the direct reaction of the present mixture in obtaining low free formaldehyde aqueous DMDMH/MDMH/DMH solutions with great stability.

TABLE 1

Direct Reaction Production of Aqueous DMDMH/MDMH/DMH		
Example	1	1A
Molar Ratio Formaldehyde : DMH	1.35:1	2:1
Total Formaldehyde (%) (Initial/Six Months)	12.4-12.6/12.3-13	13
Free Formaldehyde (%) (Initial/Six Months)	0.056-0.063/0.059-0.06	1
H_2O (%) (Initial/Six Months)	46.5-47.3/43-48.2	59
MeOH (%) (Initial/Six Months)	0.12/--	--
DMH (%) (Initial/Six Months)	3.5-3.8/--	0
MDMH (%) (Initial/Six Months)	23.1-23.2/--	7
DMDMH (%) (Initial/Six Months)	25.7-26.8/--	33
Solids (%) (Initial/Six Months)	52.5/--	40
pH (Initial/Six Months)	7.2-7.5/6.8-7.4	--

EXAMPLE 2

A 12 liter 3-necked round bottom flask equipped with a stirrer, a temperature regulator (Thermowatch™ and heating mantle), and a condenser was charged with 4093 grams of formalir (37% aqueous formaldehyde, 12% methanol) (51 moles of formaldehyde) and 33 grams water. The pH was adjusted to 8.3 using aqueous sodium hydroxide. 4874 grams (38 moles) of DMH were added at room temperature in a molar ratio of formaldehyde to DMH of 1.35:1. An exotherm was observed, and the temperature increased to 45°C. After most of the DMH dissolved, the maximum temperature was reached, and the exotherm stopped. The pH was adjusted to 7 using aqueous sodium hydroxide. The reaction was heated at 55°C for 3 hours and then was cooled to room temperature. The pH was adjusted to range from 6.8 to 7.2. 5 grams of filter aid (diatomaceous earth) were added, and the product was filtered.

Properties are summarized in Table 2.

This procedure was repeated four additional times with similar results.

TABLE 2

Direct Reaction Production of Aqueous DMDMH/MDMH/DMH	
Example	2
Molar Ratio Formaldehyde:DMH	1.35:1
Total Formaldehyde (%)	16.9
Free Formaldehyde (%)	0.04
H_2O (%)	29.1
MeOH (%)	0.26
DMH (%)	5.3
MDMH (%)	31.8
DMDMH (%)	33.4
Solids (%)	70.6

EXAMPLE 3

A 12 liter 3-necked round bottom flask equipped with a stirrer, a temperature regulator (Thermowatch™ and heating mantle), and a condenser was charged with 68.2 grams of formalin (37% formaldehyde, 1.2% methanol) (0.84 mole of formaldehyde) and 35.9 grams of water. The pH was adjusted to 8.3 using aqueous sodium hydroxide. 89.6 grams (0.7 mole) of DMH were added at room temperature in a molar ratio of formaldehyde to DMH of about 1.2:1. An exotherm was observed, and the temperature increased to 31°C. After most of the DMH dissolved, the maximum temperature was reached, and the exotherm stopped. The pH was adjusted with aqueous sodium hydroxide to 7. The reaction was heated at 55°C for three hours and was then cooled to room temperature. The pH was then adjusted to a range of from 6.8 to 7.2. 5 grams of filter aid (diatomaceous earth) were added, and the product was filtered.

Properties are summarized in Table 3.

EXAMPLE 4

The procedure of Example 3 was followed except the amount of DMH (3840 grams) (30 moles) was adjusted so that the ratio of formaldehyde to DMH was 1.3:1.

Properties are summarized in Table 3.

The procedure was repeated four additional times with similar results.

EXAMPLE 5

The procedure of Example 3 was followed except the amount of DMH (3558 grams) (27.8 moles) was adjusted so that the ratio of formaldehyde to DMH was 1.4:1.

Properties are summarized in Table 3.

EXAMPLE 6

The procedure of Example 3 was followed except the amount of DMH (3328 grams) (26 moles) was adjusted so that the ratio of formaldehyde to DMH was 1.5:1.

Properties are summarized in Table 3.

COMPARATIVE EXAMPLE 6A

The procedure of Example 3 was followed except the amount of DMH (3017 grams) (23.7 moles) was adjusted so that the ratio of formaldehyde to DMH was 1.6:1.

Properties are summarized in Table 3.

Examples 2-6, when compared with Comparative Example 6A, demonstrate that formaldehyde to DMH molar ratios as low as 1.2 and up to 1.5 but less than 1.6, when used in the direct reaction method of the present invention, result in low formaldehyde aqueous DMDMH/ MDMH/DMH solutions, while ratios of 1:6:1 do not.

TABLE 3

Direct Reaction Production of Aqueous DMDMH/MDMH/DMH					
Example	3	4	5	6	6A
Molar Ratio Formaldehyde:DMH	1.2:1	1.3:1	1.4:1	1.5:1	1.6:1
Total Formaldehyde (%)	13.1	13	13	13	13
Free Formaldehyde (%)	0.04	0.048	0.071	0.086	0.13
H_20 (%)	42.6	45.9	52.1	61.9	69
DMH (%)	5.7	7.8	5.9	3.2	2.9
MDMH (%)	29	11.8	11.8	8.4	7.6
DMDMH (%)	22.7	34.5	30.5	26.4	20.5
Solids (%)[a]	57.4	54.1	48.2	38.0	31

a - Calculated

EXAMPLE 7

A 12 liter 3-necked round bottom flask equipped with a stirrer, a temperature regulator (Thermowatch™ and heating mantle), and a condenser was charged with 4093 grams of formalin (37% formaldehyde) (51 moles of formaldehyde) and 33 grams water. The pH was adjusted to 8.3 using aqueous sodium hydroxide. 4874 grams (38 moles) of DMH were added at room temperature in a molar ratio of formaldehyde to DMH of 1.34:1. An exotherm was observed, and the temperature increased to 45°C. After most of the DMH dissolved, the maximum temperature was reached, and the exotherm stopped. The pH was adjusted to 7 using aqueous sodium hydroxide. The reaction was heated at 55°C for 3 hours and then was cooled to room temperature. The pH was adjusted to range from 6.8 to 7.2. 5 grams of filter aid (diatomaceous earth) were added, and the product was filtered. The product was then analyzed.

These procedures were repeated three additional times with similar results.

The product was then stared for six months at 25°C and subsequently analyzed again.

Representative properties are summarized in Table 4.

EXAMPLE 8

The procedure of Example 7 was followed except the amount of DMH was adjusted so that the ratio of formaldehyde to DMH was 1.37:1.

Properties are summarized in Table 4.

Examples 7 and 8, when viewed in light of Examples 2 and 4, demonstrate that a molar ratio of formaldehyde to DMH of 1.35:1 gives lowest free formaldehyde content.

TABLE 4

Direct Reaction Production of Aqueous DMDMH/MDMH/DMH		
Example	7	8
Molar Ratio Formaldehyde : DMH	1.34:1	1.37:1
Total Formaldehyde (%) (Initial/Six Months)	16.7-17/16-16.7	17
Free Formaldehyde (%) (Initial/Six Months)	0.04-0.047/0.043-0.048	0.055
H_2O (%) (Initial/Six Months)	29.2-30.8/28.5-30.6	-
DMH (%) (Initial/Six Months)	4.6-5.5/4.7-5.3	-
MDMH (%) 24.1 (Initial/Six Months)	31.1-31.8/30.5-31.8	-
DMDMH (%) (Initial/Six Months)	32.6-34.3/33.5-35.1	-
pH (Initial/Six Months)	7.1-7.34/7.03-7.24	-

EXAMPLE 9

A 500 ml 4-necked flask was charged with 128.1 grams (1 mole) of DMH, 42.8 grams (1.35 moles of para-formaldehyde) (95% formaldehyde), and 0.14 gram of sodium bicarbonate. The flask was rotated while it was heated in an oil bath at 105°C. The mixture changed from a free flowing solid blend to a flowable slurry and finally to a liquid in 55 minutes. The product was cooled to 25°C to yield a highly viscous, substantially anhydrous liquid.

The product was analyzed and found to contain 24% total formaldehyde, 0.007% free formaldehyde, and 0.91% water.

EXAMPLE 10

36.3 grams of the product of Example 9 were dissolved in 14.5 grams of water. The product was analyzed and found to contain 17% total formaldehyde, 0.03% free formaldehyde, and 29.5% water.

EXAMPLE 11

37.2 grams of the product of Example 9 were dissolved in 32 grams of water. The product was analyzed and found to contain 12.7% total formaldehyde, 0.043% free formaldehyde, and 47.1% water.

Examples 9-11 demonstrate that substantially anhydrous methylolhydantoin can be prepared by the direct reaction method of the present invention. These substantially anhydrous compositions retain low free-formaldehyde properties when diluted with water.

The Post Addition Method

EXAMPLE 12

An aqueous solution of DMDMH, pH 7.2, having 13.5% by weight of total formaldehyde was prepared by charging a 250ml 3-necked flask with 76.5 parts of a 55% aqueous solution of DMDMH. 8.5 parts of water were added while mixing with a magnetic stir bar. 15 parts of solid DMH were added at room temperature, and stirring was continued until all of the solids were dissolved The pH of the solution was 6.2 and was adjusted to 7 with aqueous sodium hydroxide. Any remaining solids were removed by filtration.

Properties are summarized in Table 5.

COMPARATIVE EXAMPLE 12A

An aqueous solution of DMDMH is prepared by mixing DMDMH powder and water to yield a 13% aqueous solution. Properties are summarized in Table 5.

EXAMPLE 13

An aqueous DMDMH/MDMH/DMH solution was prepared by adding 17.5 parts of DMH to 85 parts of a concentrated DMDMH solution having 20.7% by weight total formaldehyde and 1.2% by weight free formaldehyde.

Properties are summarized in Table 5.

COMPARATIVE EXAMPLE 13A

An aqueous DMDMH/MDMH/DMH solution was prepared according to the procedure of Example 2. However, the amount of DMH added was adjusted so that the molar ratio of formaldehyde to DMH was 2:1 and the solids content was 55%.

Properties are summarized in Table 5.

Examples 12 and 13, when compared with Comparative Examples 12A and 13A respectively, demonstrate that post addition of DMH according to the present invention reduces the free formaldehyde content of aqueous DMDMH/MDMH solutions to below 0.1 percent.

TABLE 5

Post Addition of DMH				
	12	12A	13	13A
Total Formaldehyde (%)	13.5	13	17.5	17.5
Free Formaldehyde (%)	0.03	1	0.024	1
H_2O (%)	42.2	59	--	44
MeOH (%)	0.16	--	--	--
DMH (%)	4.2	0	3.3	0
MDMH (%)	27.4	7	10	10
DMDMH (%)	26.1	33	25.3	45
Solids (%)	57.6	40	61.5	55

EXAMPLE 14

A mixture of 40 parts DMDMH powder, 50 parts water, and 10 parts of DMH was prepared.

Initially, free formaldehyde was determined to be 0.038% by weight, and after 45 days, free formaldehyde was determined to be 0.021% by weight.

Properties in summarized in Table 6.

COMPARATIVE EXAMPLE 14A

A mixture of 40 parts of DMDMH powder and 60 parts water was prepared. Free formaldehyde initially was determined to be 0.46% by weight, and after 57 days, free formaldehyde was determined to be 0.47% by weight.

Properties are summarized in Table 6.

EXAMPLE 15

A mixture of 40 parts of DMDMH powder, 45 parts water, and 15 parts of DMH was prepared.

Free formaldehyde initially was determined to be 0.009% by weight, and after 34 days, free formaldehyde was determined to be 0.019% by weight.

Properties are summarized in Table 6.

Examples 14 and 15, when compared with Comparative Example 14A, demonstrate the effectiveness of post addition of DMH in obtaining low free formaldehyde aqueous DMDMH/MDMH/DMH solutions with great stability.

TABLE 6

Stability of Reaction Products of Post Addition Method			
	14	14A	15
Methylolateddimethylhydantoins	40	40	40
H_2O	50	60	45
DMH	10	--	15
Initial Free Formaldehyde (%)	0.038	0.46	0.009
Final Free-Formaldehyde (%/Days)	0.021/45	0.47/57	0.019/34

COMPARATIVE EXAMPLE 16

A mixture of 90 parts of 55% by weight aqueous DMDMH having 1 to 1.5% by weight of free formaldehyde and 10% by weight of sodium bisulfite was prepared.

Initially, free formaldehyde was determined to be 0.01% by weight. However after 4 days, free formaldehyde levels rose to 0.13% by weight.

COMPARATIVE EXAMPLE 17

A mixture of 94 parts of 55% by weight aqueous DMDMH having 1 to 1.5% by weight of free formaldehyde and 6% by weight of ammonium carbonate was prepared.

Free formaldehyde was determined to be 0.56% by weight.

Comparative Examples 16 and 17 demonstrate that the addition of sodium bisulfite or ammonium carbonate does not reduce and maintain the free formaldehyde content of aqueous DMDMH solutions to below 0.1%.

Second DMH Addition

EXAMPLE 18

An aqueous DMDMH solution having approximately 20.7% by weight of total formaldehyde was prepared by charging a 250ml 3-necked round bottom flask equipped with a magnetic stir bar, a Thermowatch™ temperature controller, a glass stopper, and a condenser with 81.2 parts of formalin (37% formaldehyde). The pH was 3.6 and was adjusted to 8.18. A first DMH charge of 64.1 parts of DMH was added. An exotherm was observed, and the temperature rose to 43°C The solution was then heated to 45°C for three hours and subsequently was cooled to room temperature. An 11.5 part sample was removed.

A second DMH charge of 17.5 parts of DMH was added. The solution was stirred until the solids dissolved. The pH was 6.3 and was adjusted to 7 with aqueous sodium hydroxide. Any remaining solids were removed by filtration.

Properties are summarized in Table 7.

COMPARATIVE EXAMPLE 18A

The procedure of Examples 18 is followed except the second addition of DMH was deleted.

Properties are summarized in Table 7.

Example 18, when compared with Comparative Example 18A, demonstrates that post addition of DMH to DMDMH/MDMH solutions successfully lowers the free formaldehyde content to below 0.1%.

TABLE 7

Second DMH Addition		
Example	18	18A
Total Formaldehyde (%)	17.6	17.5
Free Formaldehyde (%)	0 07	1
H_2O (%)	29 9	44
MeOH (%)	0 19	--
DMH (%)	2.9	0
MDMH (%)	29.5	10
DMDMH (%)	37.1	45
Solids (%)	69.8	55

EXAMPLE 19

A stable aqueous solution of DMDMH/MDMH/DMH having a free formaldehyde content of 0.08% by weight was prepared by a direct reaction method. Subsequently, 3% by weight of DMH was added.

Free formaldehyde content was determined to be 0.051% by weight.

Example 19 demonstrates that post addition of DMH to aqueous DMDMH/MDMH/DMH solutions having a relatively low free formaldehyde content can be used to supplement a direct reaction method of preparation.

Biological Activity

The following biological procedures were used.

Procedure A

FD agar was prepared by dissolving 5 grams of beef extract, 5 grams of sodium chloride, 15 grams of agar, and 10 grams of anatone powder in 1 liter of distilled water. The mixture was heated with agitation, boiled for one minute, and subsequently sterilized at 121°C for 20 minutes. It had a final pH of 7.

A 24 hour growth of the bacteria Pseudomonas aeruginosa (ATCC No. 9027) was prepared by transferring a loopful of a daily maintained stock culture to three fresh slants of FD agar. The inoculant was spread uniformly over the surface of the slant and was incubated for 24 hours at 37°C.

The culture was harvested by washing the surface of each slant with sterile saline and by placing the effluent into a sterile container. Additional saline was added to obtain a microbial count of approximately 1×10^8 colony forming units per ml of inoculum. This was determined by standardizing each inoculum spectrophotometrically.

Procedure B

The method of Procedure A was followed substituting the bacteria Staphylococcus aureus (ATCC No. 6538) for Pseudomonas aeruginosa.

Procedure C

The method of Procedure A was followed substituting the bacteria Escherichia coli (ATCC No. 8739) for Pseudomonas aeruginosa.

Procedure D

Potato dextrose agar was prepared by dissolving 39 grams of media in 1 liter of distilled water and bringing the solution to a boil. The mixture was dispensed into a 1000 ml flask. It was autoclaved for 20 minutes at 121°C, and then 35 to 40 ml were aseptically dispensed into sterile tissue culture flasks. Final pH was 5.6.

A seven day growth of the fungus Aspergillus niger (ATCC #16404) was prepared by transferring a loopful of a seven day maintained stock culture into a tissue culture flask contain ing fresh potato dextrose agar. The inoculant was spread uniformly over the surface and was incubated for seven days at 25°C.

A seven day culture was harvested by washing the surface of the tissue culture with sterile saline containing Triton X-100 (iso-octylphenoxypolyethoxyethanol), which had been previously prepared by dissolving 8.5 grams of reagent grade sodium chloride crystals in 1 liter of distilled water, adding 0.1 gram of Triton X-100, mixing thoroughly, and sterilizing at 121°C for 20 minutes. The saline treated growth was loosened from the surface of the medium with sterile glass beads. The effluent was placed into a sterile tissue grinder and was macerated. The macerated inoculum was placed into a sterile container. Sufficient additional sterile saline was added to obtain a microbial count of approximately 1 x 10^8 colony forming units per ml of inoculum. This determination was made by an additional count of the inoculum using a Neubauer hemocytometer or a comparable chamber counting device.

Procedure E

Sabouraud dextrose agar was prepared by dissolving 65 grams of media into 1 liter of distilled water. The solution was heated with agitation and was boiled for one minute. The solution was sterilized at 121°C for 20 minutes, and it had a final pH of 5.6.

A 48 hour growth of the yeast Candida albicans (ATCC #10231) was prepared by transferring a loopful of a 48 hour maintained stock culture to two slants of fresh sabouraud dextrose agar. The inoculant was spread uniformly over the slant surface and was incubated for 48 hours at 25°C.

The yeast was harvested by washing the surface with sterile saline and placing the effluent into a sterile container. The growth was loosened from the agar surface with a sterile loop. Sufficient additional saline to obtain a microbial count of approximately 1 x 10^8 colony forming units per ml of inoculum was added. This determination was made by a visual count of the inoculum using a Neubauer hemocytometer.

EXAMPLE 20

A 10.5% Neodol solution was prepared by mixing 450 grams of a polyethylene glycol ether of a mixture of synthetic C_{12}-C_{15} fatty alcohols with an average of 12 to 15 moles of ethylene oxide (Neodol 25-12 - Shell Chemical Co.) and 3825 grams of sterile water. 0.3% by weight of a stable aqueous DMDMH/MDMH/DMH solution having less than 0.06% by weight of free formaldehyde, at least 12.5% by weight of total formaldehyde, and 3.6% by weight of DMH, based upon 100% by weight of the solution, wherein the weight ratio of DMDMH to MDMH ranges from about 1:1.25 to about 3.5:1, prepared according to the method of Example 1, was added to the 10.5% Neodol solution.

Equal volumes of the microbial suspensions prepared by Procedures A, B, and C were mixed to yield a mixed bacterial suspension.

Equal volumes of the fungus and the yeast prepared by Procedures D and E, respectively, were mixed to yield a mixed fungal suspension.

40 ml of the DMDMH/MDMH/DMH-Neodol solution above were added to each of the mixed bacterial suspension and the mixed fungal suspension at a ratio of 0.1 ml of inoculum per 20 ml of DMDMH/MDMH/DMH-Neodol solution.

Inoculation was to result in a final microbial concentration of approximately 5 x 10^6 CFU/ml of material. The inoculated material was serially diluted by aseptically transferring 1 ml of the inoculated material to a sterile test tube containing 9 ml of a phosphate buffer and mixing thoroughly. This procedure was repeated until a dilution factor of 10^6 was obtained.

Each dilution sample was plated by aseptically transferring 1 ml of each dilution to a sterile petri dish and then adding the appropriate medium. Trypticase soy agar with neutralizer, prepared by dissolving 24 grams of media and 25 ml of neutralizer stock solution in a 1 liter vessel, heating with agitation, boiling for 1 minute, and sterilizing at 121°C for 20 minutes, was added to the bacterium plates. Sabouraud dextrose agar with neutralizer, prepared by dissolving 38 grams of media and 25 ml of neutralizer stock in a 1 liter vessel, heating with agitation, boiling for one minute, and sterilizing at 121°C for 20 minutes, was added to the fungal plates. The bacteria plates were then incubated for 48 hours at 37°C, and the fungi plates were then incubated for 5 to 7 days at 25°C.

After each incubation, the growth for each test sample was quantitated and was recorded. Each test sample was quantitated at 0, 1, 3, 7, 14, 21 and 28 days of exposure time to the DMDMH/MDMH/DMH-Neodol preservative solution. The inoculated samples were stored at room temperature unless otherwise specified.

Results are illustrated in Table 8.

COMPARATIVE EXAMPLE 20A

The procedure of Example 20 was followed substituting 0.3% by weight of an aqueous solution of DMDMH having greater than 0.9% by weight of free formaldehyde and 12% by weight of total formaldehyde for the DMDMH.

Results are illustrated in Table 8.

EXAMPLE 21

The procedure of Example 20 was followed substituting 0.5% by weight of the aqueous solution of DMDMH/MDMH/DMH prepared by the method of Example 1 for the DMDMH/MDMH/DMH.

Results are illustrated in Table 8.

COMPARATIVE EXAMPLE 21A

The procedure of Example 20A was followed substituting 0.5% by weight of the aqueous solution of DMDMH/MDMH/DMH for the DMDMH/MDMH/DMH.

Results are illustrated in Table 8.

EXAMPLE 22

The procedure of Example 20 was followed substituting 0.2% by weight of an aqueous solution of DMDMH/MDMH/DMH prepared by the method of Example 2 for the DMDMH/MDMH/DMH.

Results are illustrated in Table 8.

EXAMPLE 23

The procedure of Example 22 was followed substituting a 0.4% by weight of the aqueous solution of DMDMH/MDMH/DMH for the DMDMH/MDMH/DMH.

Results are illustrated in Table 8.

COMPARATIVE EXAMPLE 23A

The procedure of Example 20 was followed except no aqueous DMDMH/MDMH/DMH solution was added to the 10% Neodol solution.

Results are illustrated in Table 8.

TABLE 8

Aqueous DMDMH/MDMH/DMH and 10% Neodol Solution							
Example	20	20A	21	21A	22	23	23A
Mixed Bacterial Inoculum (CFU/ml)							
Day 0	7.6E+6	6.7E+6	5.2E+6	3.6E+6	5.3E+6	4.1E+6	1E+7
Day 1	9E+5	1E+6	4E+5	6E+5	1E+6	6E+5	9E+6
Day 3	3.7E+4	7E+3	8E+3	1.3E+2	7E+4	1.6E+4	8E+6
Day 7	<10	<10	<10	<10	<10	<10	7E+6
Day 28 4.8E+6	<10	<10	<10	<10	<10	<10	
Mixed Fungal Inoculum (CFU/ml)							
Day 0	1E+6	4E+5	4E+5	3E+5	3E+5	6E+5	4E+5
Day 1	3E+5	4E+5	5E+3	2E+4	1.7E+5	1E+5	9E+5
Day 3	6E+4	7E+4	9E+4	9E+3	7E+4	7E+4	9E+4
Day 7	5E+3	3E+4	1E+3	1E+4	2.4E+4	3E+4	4E+4
Day 28 5.9E+5	3.8E+5	2.1E+5	1.1E+5	1.1E+5	4.5E+5	1.5E+5	

EXAMPLE 24

The procedure of Example 20 was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared by mixing 450 grams of a sodium salt of sulfated, ethoxylated lauryl alcohol $CH_3(CH_2)_{10}CH_2(OCH_2CH_2)_nOSO_3Na$ (n= 1-4) and 3825 ml of sterile water, for the 10.5% Neodol solution.

Results are illustrated in Table 9.

COMPARATIVE EXAMPLE 24A

The procedure of Comparative Example 20A was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

EXAMPLE 25

The procedure of Example 21 was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

COMPARATIVE EXAMPLE 25A

The procedure of Comparative Example 21A was followed, by substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

EXAMPLE 26

The procedure of Example 22 was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

EXAMPLE 27

The procedure of Example 23 was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

COMPARATIVE EXAMPLE 27A

The procedure of Comparative Example 23A was followed, substituting a 10.5% by weight sodium lauryl ether sulfate solution prepared according to the procedure of Example 24 for the 10.5% Neodol solution.

Results are illustrated in Table 9.

TABLE 9

Aqueous DMDMH/MDMH/DMH and 10% Sodium Laurethsulfate Solution							
Example	24	24A	25	25A	26	27	27A
Mixed Bacterial Inoculum (CFU/ml)							
Day 0	9.4E+6	6.5E+6	1E+7	3.4E+6	4.7E+6	6.2E+6	1E+7
Day 1	3.5E+4	7.5E+2	1.4E+3	<10	1E+5	1E+4	8E+6
Day 3	<10	<10	<10	<10	<10	<10	3E+5
Day 7	<10	<10	<10	<10	<10	<10	8E+5
Day 28	<10	<10	<10	<10	<10	<10	1.7E+6
Mixed Fungal Inoculum (CFU/ml)							
Day 0	5E+5	6E+5	3E+5	4E+5	5E+5	3E+5	3E+5
Day 1	9E+3	3.7E+2	1.3E+2	2E+1	1E+2	3E+1	1E+5
Day 3	<10	<10	<10	<10	<10	<10	5E+4
Day 7	<10	<10	<10	<10	<10	<10	9E+4
Day 28	<10	<10	<10	<10	<10	<10	9E+4

EXAMPLE 28

The procedure of Example 20 was followed, substituting a liquid dishwater detergent solution prepared by mixing 2700 grams of sterile water, 67.5 grams of sodium hydroxide pellets, 540 grams of dodecylbenzene sulfuric acid (Stepan BDA 96%), 99 grams of 1:1 lauric diethanolamide (Carsonol® SAL-9), 472.5 grams of sodium lauryl ether sulfate, 45 grams of Polysorbate 20 (mixture of laurate esters of sorbitol and sorbitol anhydride with about 20 moles of ethylene oxide), 45 grams of Ethanol SDA-3A, 21 grams of 0.1% sodium hydroxide, and an additional 285 grams of sterile water, for the 10.5% Neodol solution.

Results are illustrated in Table 10.

COMPARATIVE EXAMPLE 28A

The procedure of Comparative Example 20A was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

EXAMPLE 29

The procedure of Example 21 was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

COMPARATIVE EXAMPLE 29A

The procedure of Comparative Example 21A was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

EXAMPLE 30

The procedure of Example 22 was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

EXAMPLE 31

The procedure of Example 23 was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

COMPARATIVE EXAMPLE 31A

The procedure of Comparative Example 23A was followed, substituting a liquid dishwasher detergent solution prepared according to the procedure of Example 28 for the 10.5% Neodol solution.

Results are illustrated in Table 10.

Examples 20-31 illustrate that aqueous DMDMH/MDMH/DMH solutions within the scope of the present invention having less than 0.1% free formaldehyde eliminated the mixed bacterial contamination after seven days exposure in all test materials and eliminated the mixed fungal contamination after seven days of exposure in all test materials except the 10.5% Neodol solution.

Comparative Examples 20A, 21A, 24A, 25A, 28A and 29A illustrate that aqueous DMDMH solutions with greater than 1% free formaldehyde completely eliminated the mixed bacterial contamination after seven days of exposure in all test materials. The mixed fungal contamination was completely eliminated after seven days of exposure in all test materials at high total formaldehyde concentration and in all test materials except 10% Neodol at lower total formaldehyde concentrations.

Therefore, it is demonstrated that low free formaldehyde compositions of the present invention are as effective as high free formaldehyde compositions of the prior art.

TABLE 10

Aqueous DMDMH/MDMH/DMH and Liquid Dishwasher Detergent							
Example	28	28A	29	29A	30	31	31A
Mixed Bacterial Inoculum (CFU/ml)							
Day 0	2.3E+6	1.3E+6	4E+6	5.2E+6	4.2E+6	2.9E+6	1.3E+7
Day 1	<10	<10	<10	<10	3E+1	<10	1E+7
Day 3	<10	<10	<10	<10	<10	<10	4.9E+6
Day 7	<10	<10	<10	<10	<10	<10	4E+6
Day 28	<10	<10	<10	<10	<10	<10	3.2E+5
Mixed Fungal Inoculum (CFU/ml)							
Day 0	3E+5	3E+5	1E+5	1E+5	1E+5	3E+5	3E+5
Day 1	<10	9E+1	<10	3E+1	3E+2	<10	9E+4
Day 3	<10	<10	<10	<10	<10	<10	1E+5
Day 7	<10	<10	<10	<10	<10	<10	8E+5
Day 28	<10	<10	<10	<10	<10	<10	6E+4

All patents, applications, and test methods mentioned above are hereby incorporated by reference.

Claims

1. A method for producing a composition comprising dimethyloldimethylhydantoin, monomethyloldimethylhydantoin and dimethylhydantoin having less than 0.1% by weight of free formaldehyde based upon 100% by weight of said composition; and wherein the weight ratio of dimethyloldimethylhydantoin to monomethyloldimethylhydantoin ranges from 1:1.25 to 3.5:1, said method comprising reacting dimethylhydantoin and a formaldehyde-containing source, wherein the molar ratio of formaldehyde to dimethylhydantoin ranges from 1.2:1 to 1.55:1.

2. A method as defined in claim 1, wherein the molar ratio of formaldehyde to dimethylhydantoin ranges from 1.3:1 to 1.55:1.

3. A method as defined in any one of claims 1 or 2, wherein said formaldehyde-containing source comprises paraformaldehyde or an aqueous solution of formaldehyde, said aqueous solution comprising from 36 to 51% by weight of formaldehyde based upon 100% by weight of aqueous formaldehyde solution.

4. A method as defined in any one of claims 1 to 3, wherein said composition has from 10 to 25% by weight of total formaldehyde and from 2 to 6% by weight of dimethylhydantoin based upon 100% by weight of said composition.

5. A method as defined in claim 4, wherein said composition has from 12 to 17% by weight of total formaldehyde.

6. A method as defined in any one of claims 1 to 5, wherein said composition comprises an aqueous solution of dimethylolhydantoin, monomethylolhydantoin and dimethylhydantoin, said solution comprising from 20 to 40% by weight of dimethyloldimethylhydantoin based on 100% by weight of total composition.

7. A method as defined in any one of claims 1 to 6, wherein said solution of dimethyloldimethylhydantoin, monomethyloldimethylhydantoin and dimethylhydantoin comprises from 25 to 35% by weight of dimethyloldimethylhydantoin based on 100% by weight of total composition.

8. A method of producing an aqueous solution of dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin having less than 0.1% by weight of free formaldehyde based upon 100% by weight of said solu-

tion; and wherein the weight ratio of dimethyloldimethylhydantoin to monomethyloldimethylhydantoin ranges from 1:1.25 to 3.5:1, said method comprising:

(a) reacting dimethylhydantoin and an aqueous solution of formaldehyde having a pH of from 8.0 to 9.0, wherein the molar ratio of formaldehyde to dimethylhydantoin ranges from 1.3:1 to 1.55:1;
(b) adjusting the product of step (a) to a pH of about 6.5 to 7.5;
(c) heating the pH adjusted product of step (b) to from 45°C to 55°C for 2½ to 3½ hours;
(d) cooling the heated product of step (c) to about room temperature; and
(e) adjusting the product of step (d) to a pH of from 6.8 to 7.2.

9. A method of producing an aqueous solution of dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin having less than 0.1% by weight of free formaldehyde based upon 100% by weight of said solution; and wherein the weight ratio of dimethyloldimethylhydantoin to monomethyloldimethylhydantoin ranges from 1:1.25 to 3.5:1, said method comprising admixing (a) from 80 to 90% by weight of an aqueous solution of methyloldimethylhydantoin having greater than 0.1% by weight of free formaldehyde with (b) from 20 to 10% by weight of dimethylhydantoin based upon 100% by weight of aqueous methyloldimethylhydantoin solution and dimethylhydantoin combined.

10. A method as defined in claim 9, wherein said aqueous solution has from 10 to 18% by weight of total formaldehyde and from 2 to 6% by weight of dimethylhydantoin.

11. A method as defined in claim 9, wherein said aqueous solution has from 12 to 17% by weight of total formaldehyde.

12. A method as defined in any one of claims 9 to 11, wherein said aqueous solution of methyloldimethylhydantoin has from 20 to 40% by weight of dimethyloldimethylhydantoin.

13. An aqueous solution comprising dimethyloldimethylhydantoin, monomethyloldimethylhydantoin, and dimethylhydantoin, wherein the dimethyloldimethylhydantoin content is from 20 to 40% by weight and the weight ratio of dimethyloldimethylhydantoin to monomethyloldimethylhydantoin is from about 1:1.25 to 3.5:1; said solution having a total formaldehyde content of from 10 to 25 % by weight and a free formaldehyde content of less than 0.1% based upon 100% by weight of total composition.

14. An aqueous solution as defined in claim 13, having from about 2 to 6% by weight of dimethylhydantoin based upon 100% by weight of said solution.

15. An aqueous solution as defined in any one of claims 13 or 14 having from about 10 to 18% by weight of total formaldehyde.

16. An aqueous solution as defined in any one of claims 13 or 14, having from about 12 to 17% by weight of total formaldehyde.

17. An aqueous solution as defined in any one of claims 13 or 14, having about 12% by weight of total formaldehyde.

18. An aqueous solution as defined in any one of claims 13 or 14 having about 17% by weight of total formaldehyde.

19. An aqueous solution as defined in any one of claims 13 to 18 wherein said solution comprises from about 25 to 35% by weight of dimethyloldimethylhydantoin based on 100% by weight of total composition.

20. A method of retarding the microbial growth in a medium susceptible to said growth, said method comprising mixing a biocidal effective amount of a composition as defined in any one of claims 13 to 19 with said medium.

21. A method as defined in claim 20, wherein said medium is selected from a personal care product, a cosmetic product, an industrial product or a household product.

22. A composition comprising a medium susceptible to microbial growth and a biocidal effective amount of a composition as defined in any one of claims 13 to 19.

23. A composition as defined in claim 22, wherein said medium is selected from a personal care product, a cosmetic product, an industrial product or a household product.

24. A substantially anhydrous composition comprising dimethyloldimethylhydantoin and monomethyloldimethylhydantoin in a weight ratio of from about 1:1.25 to 3.5:1.

25. A substantially anhydrous composition as defined in claim 24 obtainable by reacting dimethylhydantoin and a formaldehyde-containing source, wherein the molar ratio of formaldehyde to dimethylhydantoin reacted is from about 1.2:1 to 1.55:1.

Patentansprüche

1. Verfahren zur Herstellung einer Zusammensetzung, die umfaßt: Dimethyloldimethylhydantoin, Monomethyloldimethylhydantoin und Dimethylhydantoin mit weniger als 0,1 Gew.-% freien Formaldehyds, bezogen auf 100 Gew.-% der genannten Zusammensetzung, und worin das Gewichtsverhältnis von Dimethyloldimethylhydantoin zu Monomethyloldimethylhydantoin zwischen 1:1,25 und 3,5:1 beträgt, wobei das genannte Verfahren umfaßt: das Umsetzen von Dimethylhydantoin und einer Formaldehydenthaltenden Quelle, worin das Molverhältnis von Formaldehyd zu Dimethylhydantoin zwischen 1,2:1 und 1,55:1 beträgt.

2. Verfahren nach Anspruch 1, worin das Molverhältnis von Formaldehyd zu Dimethylhydantoin zwischen 1,3:1 und 1,55:1 beträgt.

3. Verfahren nach einem der Ansprüche 1 oder 2, worin die genannte Formaldehyd-enthaldende Quelle Para-formaldehyd und eine wässrige Lösung von Formaldehyd umfaßt, und die genannte wässrige Lösung von 36 bis 51 Gew.-% Formaldehyd, bezogen auf 100 Gew.-% der wässrigen Formaldehydlösung, umfaßt.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei die genannte Zusammensetzung von 10 bis 25 Gew.-% an gesamtem Formaldehyd und von 2 bis 6 Gew.-% Dimethylhydantoin, bezogen auf 100 Gew.-% der genannten Zusammensetzung, umfaßt.

5. Verfahren nach Anspruch 4, wobei die genannte Zusammensetzung von 12 bis 17 Gew.-% an gesamtem Formaldehyd umfaßt.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei die genannte Zusammensetzung eine wässrige Lösung von Dimethylolhydantoin, Monomethylolhydantoin und Dimethylhydantoin umfaßt, und die genannte Lösung von 20 bis 40 Gew.-% Dimethyloldimethylhydantoin, bezogen auf 100 Gew.-% der Gesamtzusammensetzung, umfaßt.

7. Verfahren nach einem der Ansprüche 1 bis 6, wobei die genannte Lösung von Dimethyloldimethylhydantoin, Monomethyldimethylhydantoin und Dimethylhydantoin von 25 bis 35 Gew.-% Dimethyloldimethylhydantoin, bezogen auf 100 Gew.-% der Gesamtzusammensetzung, umfaßt.

8. Verfahren zur Herstellung einer wässrigen Lösung von Dimethyloldimethylhydantoin, Monomethyloldimethylhydantoin und Dimethylhydantoin mit weniger als 0,1 Gew.-% an freiem Formaldehyd, bezogen auf 100 Gew.-% der genannten Lösung, und wobei das Gewichtsverhältnis von Dimethyloldimethylhydantoin zu Monomethyloldimethylhydantoin zwischen 1:1,25 und 3,5:1 beträgt, wobei das genannte Verfahren umfaßt:

   (a) das Umsetzen von Dimethylhydantoin mit einer wässrigen Lösung von Formaldehyd mit einem pH-Wert von 8,0 bis 9,0, wobei das Molverhältnis von Formaldehyd zu Dimethylhydantoin zwischen 1,3:1 und 1,55:1 beträgt;
   (b) Einstellen des Produkts aus Schritt (a) auf einen pH-Wert von etwa 6,5 bis 7,5;
   (c) Erhitzen des so auf den pH-Wert eingestellten Produkts nach Schritt (b) auf 45° C bis 55° C für eine Dauer von 2½ bis 3½ Stunden;
   (d) Kühlen des erhitzen Produkts aus Schritt (c) auf etwa Raumtemperatur und
   (e) Einstellen des pH-Wertes des Produkts aus Schritt (d) auf einen pH-Wert von 6,8 bis 7,2.

9. Verfahren zur Herstellung einer wässrigen Lösung von Dimethyloldimethylhydantoin, Monomethyloldimethylhydantoin und Dimethylhydantoin mit weniger als 0,1 Gew.-% an freiem Formaldehyd, bezogen auf 100 Gew.-% der genannten Lösung, wobei das Gewichtsverhältnis von Dimethyloldimethylhydantoin zu Monomethyloldimethylhydantoin zwischen 1:1,25 und 3,5:1 beträgt, wobei das genannte Verfahren umfaßt: Das Mischen (a) von 80 bis 90 Gew.-% einer wässrigen Lösung von Methyloldimethylhydantoin mit mehr als 0,1 Gew.-% an freiem Formaldehyd mit (b) von 20 bis 10 Gew.-% Dimethylhydantoin, bezogen auf 100 Gew.-% wässriger Methyloldimethylhydantoin-Lösung kombiniert mit Dimethylhydantoin.

10. Verfahren nach Anspruch 9, worin die genannte wässrige Lösung von 10 bis 18 Gew.-% an gesamtem Formaldehyd und von 2 bis 6 Gew.-% Dimethylhydantoin umfaßt.

11. Verfahren nach Anspruch 9, wobei die genannte wässrige Lösung von 12 bis 17 Gew.-% an gesamtem Formaldehyd umfaßt.

12. Verfahren nach einem der Ansprüche 9 bis 11, wobei die genannte wässrige Lösung von Methyloldimethylhydantoin von 20 bis 40 Gew.-% Dimethyloldimethylhydantoin umfaßt.

13. Wässrige Lösung, die Dimethyloldimethylhydantoin, Monomethyloldimethylhydantoin und Dimethylhydantoin umfaßt, worin der Gehalt an Dimethyloldimethylhydantoin von 20 bis 40 Gew.-% und das Gewichtsverhältnis von Dimethyloldimethylhydantoin zu Monomethyloldimethylhydantoin von etwa 1:1,25 bis 3,5:1 beträgt, wobei die genannte Lösung einen Gesamtgehalt an Formaldehyd von 10 bis 25 Gew.-% und einen Gehalt an freiem Formaldehyd von weniger als 0,1%, bezogen auf 100 Gew.-% der Gesamtzusammensetzung, umfaßt.

14. Wässrige Lösung nach Anspruch 13, die von etwa 2 bis 6 Gew.-% Dimethylhydantoin, bezogen auf 100 Gew.-% der genannten Lösung, umfaßt.

15. Wässrige Lösung nach einem der Ansprüche 13 oder 14, die von etwa 10 bis 18 Gew.-% an gesamtem Formaldehyd umfaßt.

16. Wässrige Lösung nach einem der Ansprüche 13 oder 14, die von etwa 12 bis 17 Gew.-% an gesamtem Formaldehyd umfaßt.

17. Wässrige Lösung nach einem der Ansprüche 13 oder 14, die etwa 12 Gew.% an gesamtem Formaldehyd umfaßt.

18. Wässrige Lösung nach einem der Ansprüche 13 oder 14, die etwa 17 Gew.% an gesamtem Formaldehyd umfaßt.

19. Wässrige Lösung nach einem der Ansprüche 13 bis 18, wobei die genannte Lösung von etwa 25 bis 35 Gew.-% Dimethyloldimethylhydantoin, bezogen auf 100 Gew.-% der Gesamtzusammensetzung, umfaßt.

20. Verfahren zur Verzögerung des mikrobiellen Wachstums in einem Medium, das gegenüber diesem Wachstum zugänglich ist, wobei das genannte Verfahren das Mischen einer als Biozid wirksamen Menge einer Zusammensetzung nach einem der Ansprüche 13 bis 19 mit dem genannten Medium umfaßt.

21. Verfahren nach Anspruch 20, worin das genannte Medium ausgewählt wird aus einem Körperpflegeprodukt, einem kosmetischen Produkt, einem gewerblichen Produkt oder einem Haushaltsprodukt.

22. Zusammensetzung, die ein gegenüber mikrobiellem Wachstum zugängliches Medium und eine als Biozid wirksame Menge einer Zusammensetzung nach einem der Ansprüche 13 bis 19 umfaßt.

23. Zusammensetzung nach Anspruch 22, wobei das genannte Medium ausgewählt wird aus einem Körperpflegeprodukt, einem kosmetischen Produkt, einem gewerblichen Produkt oder einem Haushaltsprodukt.

24. Im wesentlichen wasserfreie Zusammensetzung, die Dimethyloldimethylhydantoin und Monomethyloldimethylhydantoin in einem Gewichtsverhältnis von etwa 1:1,25 bis 3,5:1 umfaßt.

25. Im wesentlichen wasserfreie Zusammensetzung nach Anspruch 24, erhalten durch Umsetzung von Dimethylhydantoin und einer Formaldehyd-enthaltenden Quelle, wobei das Molverhältnis von Formaldehyd zu Dimethylhydantoin von etwa 1,2:1 bis 1,55:1 beträgt.

Revendications

1. Une méthode de production d'un composé chimique comprenant du diméthyloldiméthylhydantoïne, du monométhyloldiméthylhydantoïne et du diméthylhydantoïne, ayant moins de 0,1 % en poids de formaldéhyde libre basé sur 100 % du poids dudit composé; et où le rapport de poids du diméthyloldiméthylhydantoïne au monométhyloldiméthylhydantoïne va de 1:1,25 à 3,5:1, ladite méthode comprenant du diméthylhydantoïne réactif et une source contenant du formaldéhyde, où le rapport molaire du formaldéhyde au diméthylhydantoïne va de 1,2:1 à 1,55:1.

2. Une méthode ainsi qu'elle est définie dans la déclaration 1, ou le rapport molaire du formaldéhyde au diméthylhydantoïne va de 1,3:1 à 1,55:1.

3. Une méthode telle qu'elle est définie dans la déclaration 1 ou 2, où ladite source contenant du formaldéhyde est composée de paraformaldéhyde ou d'une solution aqueuse de formaldéhyde, ladite solution aqueuse comprenant de 36 à 51 % en poids de formaldéhyde basé sur 100 % du poids de solution aqueuse de formaldéhyde.

4. Une méthode telle qu'elle est définie dans l'une des déclarations de 1 à 3, où ledit composé a de 10 à 25 % en poids de formaldéhyde total et de 2 à 6 % en poids de diméthylhydantoïne basé sur 100 % du poids dudit composé.

5. Une méthode telle qu'elle est définie dans la déclaration 4, où ledit composé a de 12 à 17 % en poids de formaldéhyde total.

6. Une méthode telle qu'elle est définie dans l'une des déclarations de 1 à 5, où ledit composé comprend une solution aqueuse de diméthylolhydantoïne, monométhylolhydantoïne et diméthylhydantoïne, ladite solution comprenant de 20 à 40 % en poids de diméthyloldiméthylhydantoïne basé sur 100 % du poids du composé total.

7. Une méthode telle qu'elle est définie dans l'une des déclarations de 1 à 6, où ladite solution de diméthyloldiméthylhydantoïne, monométhyloldiméthylhydantoïne et diméthylhydantoïne comprend de 25 à 35 % en poids de diméthyloldiméthylhydantoïne basé sur 100 % du poids du composé total.

8. Une méthode de production d'une solution aqueuse de diméthyloldiméthylhydantoïne, monométhyloldiméthylhydantoïne, et diméthylhydantoïne ayant moins de 0,1 % du poids de formaldéhyde libre basé sur 100 % du poids de ladite solution, et où le rapport de poids du diméthyloldiméthylhydantoïne au monométhyloldiméthylhydantoïne va de 1:1,25 à 3,5:1, ladite méthode comprenant:

   (a) du diméthylhydantoïne réactif et une solution aqueuse de formaldéhyde ayant un pH entre 8,0 et 9,0, où le rapport molaire du formaldéhyde au diméthylhydantoïne va de 1,3:1 à 1,55:1;
   (b) l'ajustement du produit de l'étape (a) à un pH d'environ 6,5 à 7,5;
   (c) le chauffage du produit au pH ajusté de l'étape (b) de 45°C à 55°C pendant 2 heures et demi à 3 heures et demi ;
   (d) le refroidissement du produit chauffé de l'étape (c) à température ambiante; et
   (e) l'ajustement du produit de l'étape (d) à un pH entre 6,8 et 7,2.

9. Une méthode de production d'une solution aqueuse de diméthyloldiméthylhydantoïne, monométhyloldiméthylhydantoïne et de diméthylhydantoïne ayant moins de 0,1 % en poids de formaldéhyde libre basé sur 100 % du poids de ladite solution; et où le rapport de poids du diméthyloldiméthylhydantoïne au monométhyloldiméthylhydantoïne va de 1:1,25 à 3,5:1, ladite méthode comprenant le mélange additionnel de (a) de 80 à 90 % en poids d'une solution aqueuse de méthyloldiméthylhydantoïne ayant plus de 0,1 % en poids de formaldéhyde libre avec (b) de 20 à 10 % en poids de diméthylhydantoïne basé sur 100 % du poids d'une solution aqueuse de méthyloldiméthylhydantoïne et de diméthylhydantoïne combinés.

10. Une méthode telle qu'elle est définie dans la déclaration 9, où ladite solution aqueuse a de 10 à 18 % du poids de formaldéhyde total et de 2 à 6 % en poids de diméthylhydantoïne.

11. Une méthode telle qu'elle est définie dans la déclaration 9, où ladite solution aqueuse a de 12 à 17 % du poids de formaldéhyde total.

12. Une méthode telle qu'elle est définie dans l'une des déclarations de 9 à 11, où ladite solution aqueuse de méthyloldiméthylhydantoïne a de 20 à 40 % en poids de diméthyloldiméthylhydantoïne.

13. Une solution aqueuse comprenant du diméthyloldiméthylhydantoïne, du monométhyloldiméthylhydantoïne et du diméthylhydantoïne, où le contenu de diméthyloldiméthylhydantoïne est de 20 à 40 % en poids et le rapport de poids du diméthyloldiméthylhydantoïne au monométhyloldiméthylhydantoïne est d'environ 1:1,25 à 3,5:1; ladite solution ayant un contenu total de formaldéhyde de 10 à 25 % on poids et un contenu de formaldéhyde libre de moins de 0,1 % basé sur 100 % du poids du composé total.

14. Une solution aqueuse telle qu'elle est définie dans la déclaration 13, ayant de 2 à 6 % en poids de diméthylhydantoïne basé sur 100 % du poids de ladite solution.

15. Une solution aqueuse telle qu'elle est définie dans la déclaration 13 ou 14 ayant de 10 à 18 % du poids de formaldéhyde total.

16. Une solution aqueuse telle qu'elle est définie dans la déclaration 13 ou 14, ayant de 12 à 17 % du poids de formaldéhyde total.

17. Une solution aqueuse telle qu'elle est définie dans la déclaration 13 ou 14, ayant environ 12 % du poids de formaldéhyde total.

18. Une solution aqueuse telle qu'elle est définie dans la déclaration 13 ou 14, ayant environ 17 % du poids de formaldéhyde total.

19. Une solution aqueuse telle qu'elle est définie dans la déclaration 13 ou 18, où ladite solution comprend de 25 à 35 % en poids de diméthyloldiméthylhydantoïne basé sur 100 % du poids du composé total.

20. Une méthode pour retarder la croissance microbienne dans un milieu susceptible à ladite croissance, ladite méthode comprenant le mélange d'une quantité biocide efficace d'un composé avec ledit milieu, ainsi qu'il est défini dans l'une des déclarations de 13 à 19.

21. Une méthode telle qu'elle est définie dans la déclaration 20, où ledit milieu est sélectionné parmi un objet de toilette personnel, un produit cosmétique, un produit industriel ou un produit ménager.

22. Un composé comprenant un milieu susceptible à la croissance microbienne et une quantité biocide efficace d'un composé chimique ainsi qu'il est défini dans l'une des déclarations 13 à 19.

23. Un composé tel qu'il est défini dans la déclaration 22, où ledit milieu est sélectionné parmi un objet de toilette personnel, un produit cosmétique, un produit industriel ou un produit ménager.

24. Un composé pratiquement anhydre comprenant du diméthyloldiméthylhydantoïne et du monométhyloldiméthylhydantoïne dans un rapport de poids d'environ 1:1,25 à 3,5:1.

25. Un composé pratiquement anhydre tel qu'il est défini dans la déclaration 24 pouvant être obtenu en faisant réagir du diméthylhydantoïne et une source contenant du formaldéhyde, où le rapport molaire du formaldéhyde au diméthylhydantoïne réactif est d'environ 1,2:1 à 1,55:1.